

902250

FINAL DRAFT COPY

AD

①

REPORT NO. 729

THE RELATION OF INDUCED TINNITUS TO PHYSICAL
CHARACTERISTICS OF THE INDUCING STIMULI

(Interim Report)

by

Michel Loeb, Ph.D.*

and

Richard P. Smith, Ph.D.**

* Experimental Psychology Division
US ARMY MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky 40121

** Department of Psychology
UNIVERSITY OF LOUISVILLE
Louisville, Kentucky 40208

10 May
April 1967

DDC
RECEIVED
MAY 23 1967
RECEIVED

Audition and Auditory Perception
Work Unit No. 030
Basic Research in Performance Effectiveness
Task No. 00
Basic Research in Performance Effectiveness
DA Project No. 3A014501B74C

Distribution of this document is unlimited.

19

Disposition

Destroy this report when no longer needed. Do not return it to the originator.

USAMRL Report No. 7289
DA Project No. 3A014501B74C

ABSTRACT

OBJECTIVE

To determine the relationship between the frequency of temporary threshold shift (TTS), the pitch of induced tinnitus (IT), and the frequency of the inducing stimulus.

METHOD

Observers were exposed monaurally to four pure tones, to white noise, and to three octave bands of noise at levels sufficient to induce tinnitus. They were asked to match the frequency of the tinnitus by manipulating the frequency of a tone in the opposite ear, and their TTS was then measured on a Békésy audiometer.

SUMMARY

Both frequency of maximum TTS and pitch of induced tinnitus increased with frequency of the inducing stimulus; however, they did not coincide.

CONCLUSION

One should be hesitant in assuming that when an individual has a tinnitus of a certain frequency that his maximum hearing loss is at that frequency.

ACKNOWLEDGMENTS

This research was facilitated by a contract between the Office of The Surgeon General, US Army, and the University of Louisville. We are indebted to the staff of Kentucky State Reformatory, LaGrange, and especially to Mr. Leo S. Yarutis, Psychologist, LaGrange State Reformatory, for the administrative arrangements making this experiment possible. We are also indebted

to Messrs. Carl Guthrie, William Gresham, William LaVigne, and Kenneth Woodard for technical assistance. A preliminary version of this paper was presented at the 1966 (Boston) meeting of the Acoustical Society of America.

APPROVED: _____

GEORGE S. HARKER, Ph.D.
Director, Experimental Psychology
Division

APPROVED: _____

HOWARD H. CRAIG
COL, MSC
Director

THE RELATION OF INDUCED TINNITUS TO PHYSICAL
CHARACTERISTICS OF THE INDUCING STIMULI

Michel Loeb

US Army Medical Research Laboratory, Fort Knox, Kentucky 40121

Richard P. Smith

University of Louisville, Louisville, Kentucky 40208

THE RELATION OF INDUCED TINNITUS TO PHYSICAL
CHARACTERISTICS OF THE INDUCING STIMULI

ABSTRACT

After observers were exposed to intense pure tones and broad band acoustic stimuli, their temporary threshold shifts were measured, and they were asked to match the pitch of any resulting tinnitus by manipulating the frequency of an adjustable low-level pure tone in the opposite ear. It was found that both the frequency of tinnitus and the frequency of the tone used for the pitch match increased as the frequency of the traumatic stimulus increased, but maximum loss frequency and tinnitus frequency did not coincide. Although the observers were quite reliable in their judgments of tinnitus elicited by a stimulus, inter-observer variability was considerable.

THE RELATION OF INDUCED TINNITUS TO PHYSICAL
CHARACTERISTICS OF THE INDUCING STIMULUS

Michel Loeb

US Army Medical Research Laboratory, Fort Knox, Kentucky 40121

Richard P. Smith

University of Louisville, Louisville, Kentucky 40208

There has been a considerable number of experiments concerned with the nature and extent of permanent or long-lasting tinnitus aurium. (For a recent comprehensive review, see Graham, 1965.) Generally, investigators have asked patients with hearing disabilities to describe their tinnitus and to match it to an external stimulus in frequency and intensity; they have then attempted, with varying degrees of success, to relate their findings to type of hearing loss and to the frequency of maximum loss. Graham and Newby (1962) have reported that patients with conductive losses reported tinnitus in a more restricted, low-frequency range than patients with sensorineural or mixed losses or normal individuals. Relatively few studies have been reported on the characteristics of tinnitus associated with temporary hearing losses. Ward (1963) reported that most commonly such tinnitus is a broadband noise resembling that produced by a waterfall, that when it is tonal it tends to be of relatively high frequency (2000-6000 cps), and that it does, to some extent, mask a test tone of similar frequency, especially when the test tone is continuous.

There have been no experiments, to the authors' knowledge, in which tinnitus was deliberately induced in normal subjects and the relationship

Loeb and Smith

of the characteristics of the induced tinnitus and those of the inducing stimuli and of the temporary threshold shift were systematically studied. The experiment to be described represents an initial attempt to do so.

PROCEDURE

Eight stimuli were employed for production of tinnitus--a 500 cps tone, a 1000 cps tone, a 2000 cps tone, a 3000 cps tone, a white noise, a 600-1200 cps noise, a 1200-2400 cps noise, and a 2400-4800 cps noise. Exposure was in the right ear, under free field conditions; the left ear was plugged with a Com-Fit earplug or Willson muff. Subjects were tested before and after exposure with a Grason-Stadler Békésy type audiometer, beginning at 500 cps. The fast scanning speed was employed and testing was initiated 90 sec after exposure. Test stimuli were pulsed, and initial level for the exposure stimulus was 90 dB. Exposure duration was 5 minutes.

Each S was run repetitively with each exposure stimulus until he had a TTS as great as 40 dB or until the stimulus level was 120 dB. Each subject was asked immediately following exposure whether he noticed any sound within his ears or head. If such a sound was experienced, an earphone was placed on his left (unexposed) ear, he was asked to describe the sound, and it was requested that he manipulate the controls of a Hewlett-Packard transistor oscillator to match the pitch of the sound that he heard. The intensity level of the transistor oscillator was set at a low level (approximately 20 dB sensation level), usually in the 1000-3000 cps range, and observers were allowed to change intensity setting as well as frequency setting.

Subjects. All subjects were inmates of the Kentucky State Reformatory (an adult penal institution) at LaGrange, Ky. Their scores on a non-verbal

Loeb and Smith

Intelligence test (Army Beta) were available, and preliminary audiometry was performed; those with Beta test scores below 90, achievement scores below the seventh grade level, or hearing levels in excess of 20 dB (ASA) at or below 4000 cps were rejected. Participation was voluntary and subjects were paid for participating.

RESULTS AND DISCUSSION

In order to obtain a moderately large sample, differing numbers of Ss had to be obtained for the different exposure conditions; moreover, some of the Ss were employed for several exposures and some were not. It is not possible, therefore, to perform a precise statistical test of the difference in mean pitch match between exposure conditions. Subjects were tested twice at the highest exposure level employed to determine whether there were pitch matches under each condition characteristic of the individual.

Table I summarizes a number of the experimental results.

Insert Table I about here

For each exposure condition there was considerable intersubject variability, both for the frequency of pitch match and frequency of maximum loss. Furthermore, the distributions of these were quite skewed. For this reason, median and semi-interquartile ranges (Qs) were computed as indices of central tendency and variability, respectively.

It is apparent that there is a general tendency for both the median pitch match frequency and the median frequency of maximum loss to increase as the frequency of the eliciting stimulus increases. However, the two neither generally coincide nor increase at the same rate. For the pure-tone eliciting

Loeb and Smith

stimulus, the increase with increasing frequency of eliciting stimulus is generally greater. With the noise eliciting stimuli, pitch match frequencies were generally higher than maximum loss frequencies.

It is obvious from Table I that both maximum loss (M) and pitch match (PM) frequencies were quite variable within the groups, and it might be asked whether subjects were able to match this subjective tinnitus reliably. At the maximum exposure level, each observer was exposed twice and the test-retest (reliability) coefficients obtained. It is apparent (Table II) that in general the observers were fairly reliable in their pitch matches, though it is, of course, impossible to make any statement about the validity of their judgment.

Insert Table II about here

One other finding appears worthy of comment. Although Ward (1963) reported that previous investigators have generally reported "noisy" rather than tonal tinnitus, this was not the case in the present experiment. Only three subjects reported a "buzz" or "Alka-Seltzer" type of noise, though these observers were told that such a tinnitus might occur and were encouraged to report it. Several did report hearing complex tones; they were instructed to match the most prominent element of the reported complexes.

CONCLUSIONS

1. Tinnitus elicited by tones and broad-band noise is generally tonal rather than "noisy."

2. It cannot be assumed that the reported tinnitus coincides with the frequency of maximum loss, when the tinnitus and loss are temporary and when the hearing of the subjects falls within normal limits.

Loeb and Smith

3. Pitch of tinnitus tends to increase with frequency of the eliciting stimulus, but individual differences are considerable.

ACKNOWLEDGMENTS

This research was facilitated by a contract between the Office of The Surgeon General, US Army, and the University of Louisville. We are indebted to the staff of Kentucky State Reformatory, LaGrange, and especially to Mr. Leo S. Yarutis, Psychologist, LaGrange State Reformatory, for the administrative arrangements making this experiment possible. We are also indebted to Messrs. Carl Guthrie, William Gresham, William LaVigne, and Kenneth Woodard for technical assistance. A preliminary version of this paper was presented at the 1966 (Boston) meeting of the Acoustical Society of America.

REFERENCES

- GRAHAM, J. T. (1965). "Tinnitus Aurium," *Acta Otolaryngologica*, Suppl. 202.
- GRAHAM, J. T. and NEWBY, H. A. (1962). "Acoustical Characteristics of Tinnitus," *Arch. Otolaryng.*, 75, 162-167.
- WARD, W. D., "Auditory Fatigue and Masking," in Modern Advances in Audiology, J. Jerger, Ed. (Academic Press, New York, 1963), Chap. 7, pp. 240-286.

ML/nwb

TABLE I

SUMMARY DATA RELATING TO TINNITUS AND TEMPORARY THRESHOLD SHIFT

Stimulus	N	Pitch Match (PM) of Tinnitus		Frequency of Maximum Loss (M)		Loss at PM dB	Loss at H dB	Mean Ring Level dB	Mean Test Level dB
		Mdn	Q	Mdn	Q				
500 cps	12 ¹	1025	1845	970	2500	7.0	14.6	114.5	119.1
1000 cps	10	3378	1896	1275	381	17.9	32.7	114.5	117.0
2000 cps	11 ²	5575	3815	3750	550	12.6	25.1	114.4	118.6
4000 cps	12 ³	6200	2432	4500	1019	21.3	32.3	116.0	118.5
Noises: white	9	2750	808	5000	1786	13.3	24.9	109.4	111.2
500-1200 cps	10 ²	872	466	3187	1112	5.6	18.3	114.6	116.4
1200-2400 cps	10	2582	1514	3875	1198	11.6	22.6	113.5	117.0
2400-4800 cps	12	3693	838	5150	1650	6.54	22.8	110.0	114.6

¹ Five additional individuals reported no tinnitus at the highest exposure level employed.

² Two additional individuals reported no tinnitus at highest exposure level.

³ Three additional individuals reported no tinnitus at highest level.

Ring level" is the level at which the observer first noticed a tinnitus; "test level" is the highest level employed, at which the other data were gathered.

TABLE II
TEST-RETEST RELIABILITIES FOR PITCH MATCHES
(PEARSON CORRELATIONS)

Eliciting Stimulus							
500 cps	1000 cps	2000 cps	3000 cps	white noise	600-1200 cps	1200-2400 cps	2400-4800 cps
.83 ¹	.11 ²	.90 ¹	.50 ³	0.92	0.83 ³	0.90 ³	.89 ¹

¹Statistically significant beyond the 0.01 level.

²Not significant. However, the distribution contains one very extreme value. If the pair containing this value is eliminated, the test-retest correlation is 0.89 (significant beyond the 0.01 level); if the pair is retained and the Spearman rank order test-retest correlation computed, test-retest correlation is 0.65 (significant beyond the 0.025 level). In a later replication of exposures to this stimulus, a reliability of 0.79 was obtained for 14 observers.

³Statistically significant at the 0.05 level.

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) US Army Medical Research Laboratory Fort Knox, Kentucky 40121		2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	
		2b. GROUP	
3. REPORT TITLE THE RELATION OF INDUCED TINNITUS TO PHYSICAL CHARACTERISTICS OF THE INDUCING STIMULI			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Interim			
5. AUTHOR(S) (First name, middle initial, last name) Michel Loeb, Ph.D. Richard P. Smith, Ph.D.			
6. REPORT DATE April 1967 10 May 1967		7a. TOTAL NO. OF PAGES 5	7b. NO. OF REFS 3
8a. CONTRACT OR GRANT NO.		9a. ORIGINATOR'S REPORT NUMBER(S) 729	
b. PROJECT NO. 3A014501B74C		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) * Final draft copy.	
c. Task No. 00			
d. Work Unit No. 030			
10. DISTRIBUTION STATEMENT Distribution of this document is unlimited.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY US Army Medical Research and Development Command, Washington, D. C. 20315	
13. ABSTRACT After observers were exposed to intense pure tone and broad band acoustic stimuli, their temporary threshold shifts were measured, and they were asked to match the pitch of any resulting tinnitus by manipulating the frequency of an adjustable low-level pure tone in the opposite ear. It was found that both the frequency of tinnitus and the frequency of the tone used for the pitch match increased as the frequency of the traumatic stimulus increased, but maximum loss frequency and tinnitus frequency did not coincide. Although the observers were quite reliable in their judgments of tinnitus elicited by a stimulus, inter-observer variability was considerable. (u)			

DD FORM 1473

FORM
1 NOV 61REPLACES DD FORM 1473, 1 JAN 64, WHICH IS
OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
1. Tinnitus 2. Auditory fatigue 3. Pitch match 4. Hearing loss 5. Physical-physiological relationships 6. Traumatic exposures 7. Psychoacoustics						

UNCLASSIFIED

Security Classification